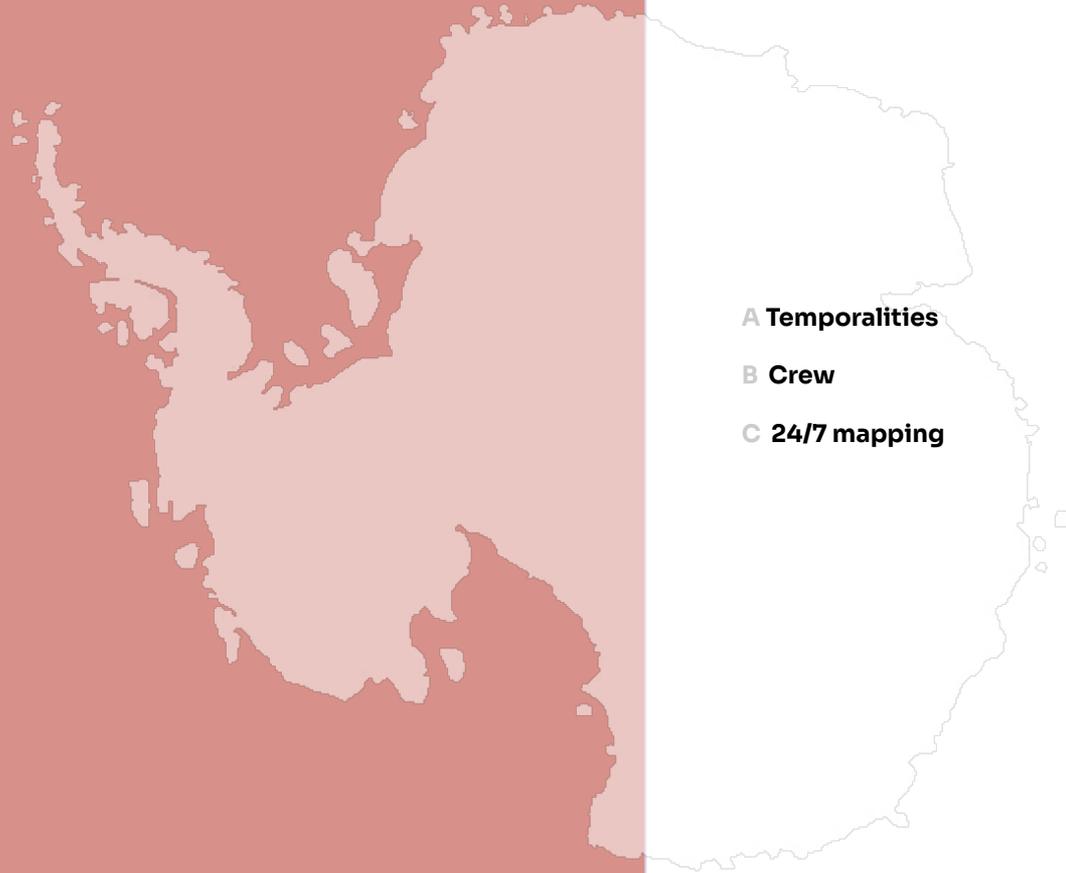




Troll Research Station Midterm Presentation

01 Context



A Temporalities

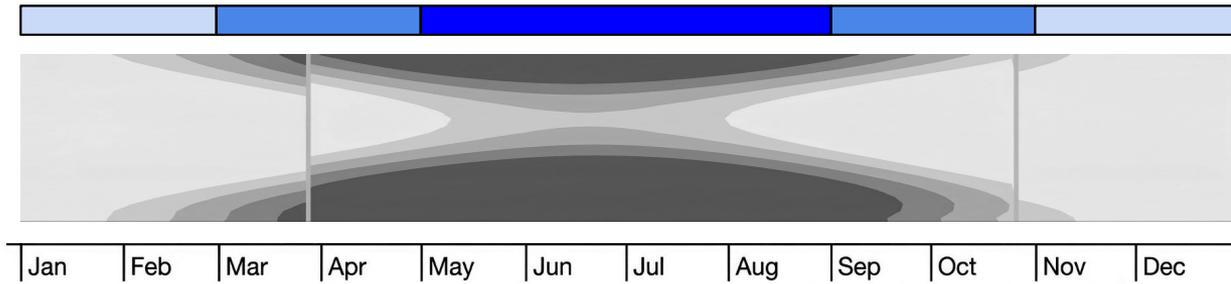
B Crew

C 24/7 mapping

Temporalities

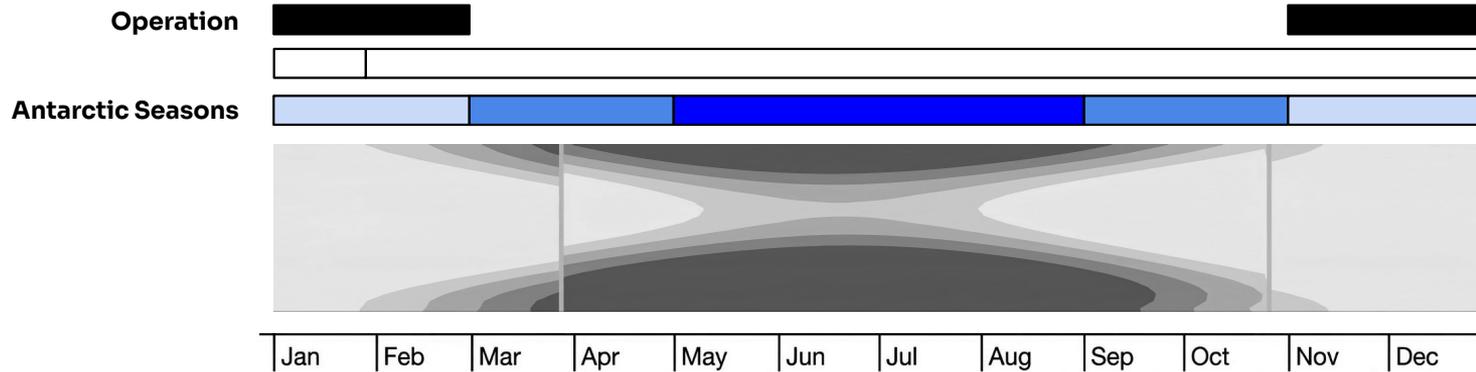
- Antarctic Summer (4 months)
- Antarctic Winter (4 months)
- Transition (Spring+Autumn, 4 months)

Antarctic Seasons

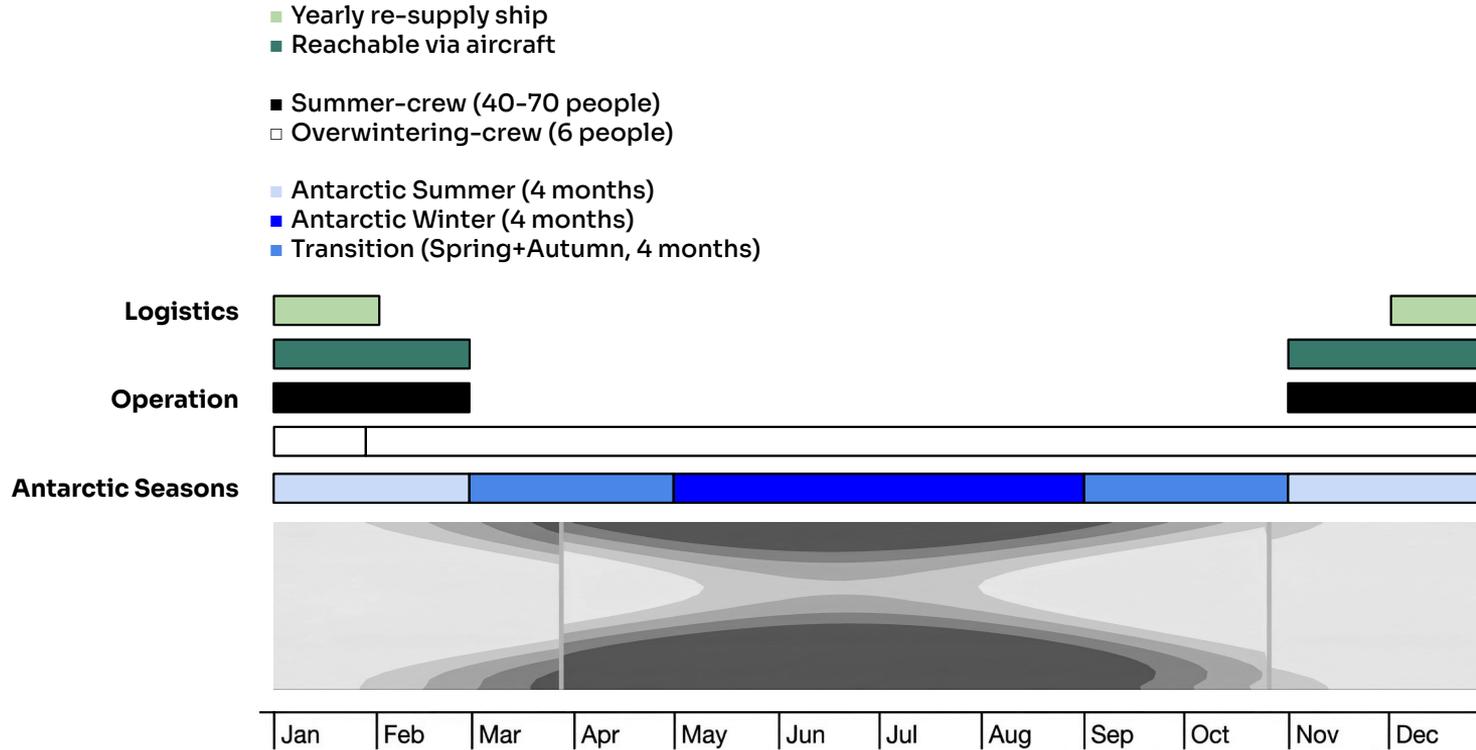


Temporalities

- Summer-crew (40-70 people)
- Overwintering-crew (6 people)
- Antarctic Summer (4 months)
- Antarctic Winter (4 months)
- Transition (Spring+Autumn, 4 months)



Temporalities





Overwintering crew

01 Station Leader

- + Station Coordination
- + Safety Oversight
- + Norway & Mission Control Communication
- + Operational Planning
- + Emergency Decision-Making
- + Infrastructure Inspections

02 Mechanical Engineer/Technician

- + monitoring electrical systems
- + maintaining sensors and scientific instruments
- + troubleshooting electronic equipment
- + supporting station technical infrastructure

03 Electrical Engineer/Systems Technician

- + maintenance of generators
- + heating and fuel systems
- + repair of vehicles and mechanical equipment
- + inspection of infrastructure
- + workshop maintenance and spare part preparation

04 Atmospheric Scientist/ Meteorologist

- + weather observations
- + atmospheric measurements
- + operation of monitoring instruments
- + climate data analysis and reporting to international network

05 Cook/Logistics Coordinator

- + meal preparation for crew
- + management of food storage and inventory
- + kitchen hygiene monitoring
- + long-term food supplies

06 Communications + Medical officer

- + operation of communication systems
- + management of satellite links and IT infrastructure
- + coordination of external communication
- + medical monitoring and emergency response

01 Context

Overwintering crew

**01
Station Leader**

Niels

- + Station Coordination
- + Safety Oversight Norway & Mission Control
- + Communication
- + Operational Planning
- + Emergency Decision-Making
- + Infrastructure Inspections

**02
Mechanical Engineer/Technician**

Sohyun

- + monitoring electrical systems
- + maintaining sensors and scientific instruments
- + troubleshooting electronic equipment
- + supporting station technical infrastructure

**03
Electrical Engineer/Systems Technician**

Luca

- + maintenance of

- 1) Daily Rhythm
- 2) Spatial Needs
- 3) Lighting Preferences
- 4) Acoustic Sensitivity
- 5) Environmental Comfort
- 6) Storage demand and ownership
- 7) Conflict management
- 8) Individual Needs / Rituals:
- 9) Private Time Demand
- 10) Sleep Window

**04
Atmospheric Scientist/Meteorologist**

Aashna

- + weather observations

**05
Cook/Logistics Coordinator**

Ilai

- + meal preparation for crew
- + management of food storage and inventory
- + kitchen hygiene monitoring
- + long-term food supplies

**06
Communications + Medical officer**

Anaelle

- + operation of communication systems
- + management of satellite links and IT infrastructure
- + coordination of external communication
- + medical monitoring and emergency response

01 Context

Occupancy of container

01
Station Leader

02
Mechanical
Engineer/Technician

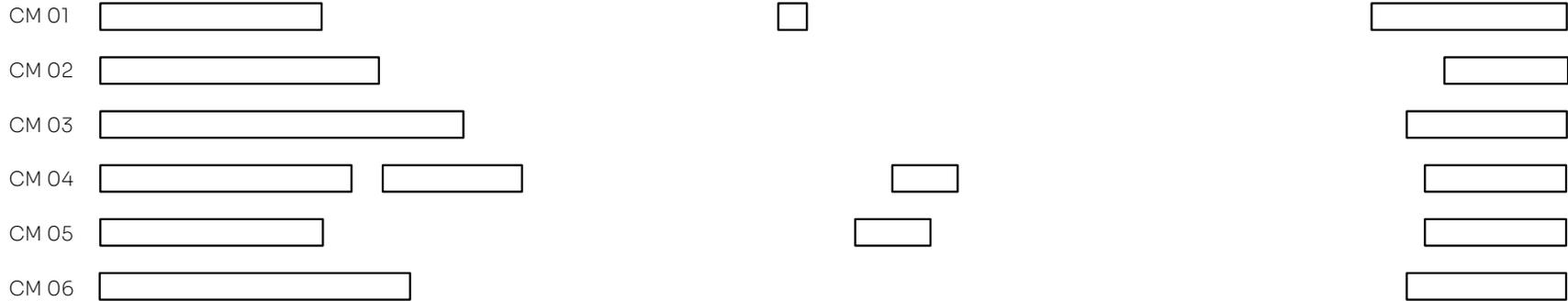
03
Electrical
Engineer/Systems
Technician

04
Atmospheric
Scientist/
Meteorologist

05
Cook/Logistics
Coordinator

06
Communications +
Medical officer

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24



01 Context

Occupancy of container

01
Station Leader

02
Mechanical
Engineer/Technician

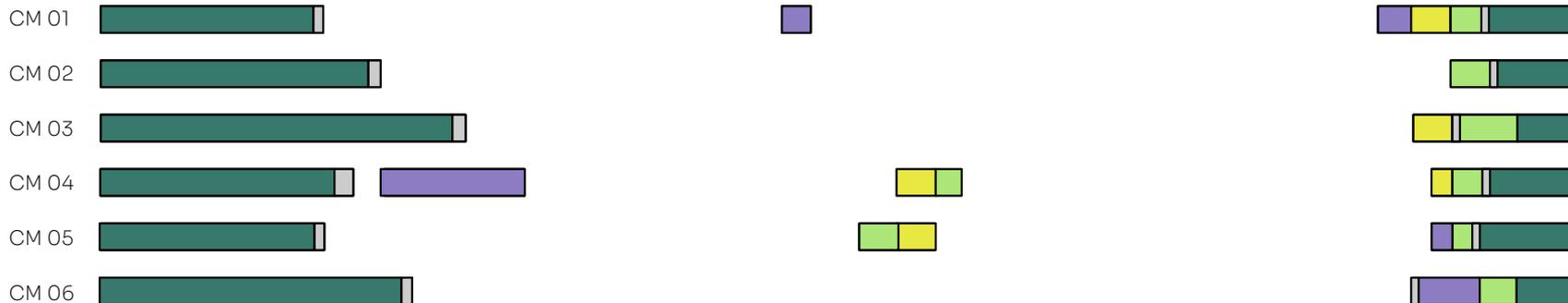
03
Electrical
Engineer/Systems
Technician

04
Atmospheric
Scientist/
Meteorologist

05
Cook/Logistics
Coordinator

06
Communications +
Medical officer

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24



Micro-socializing

Sleeping

Resting

Individual Task

Personal storage

01 Context

Occupancy of container

01
Station Leader

02
Mechanical
Engineer/Technician

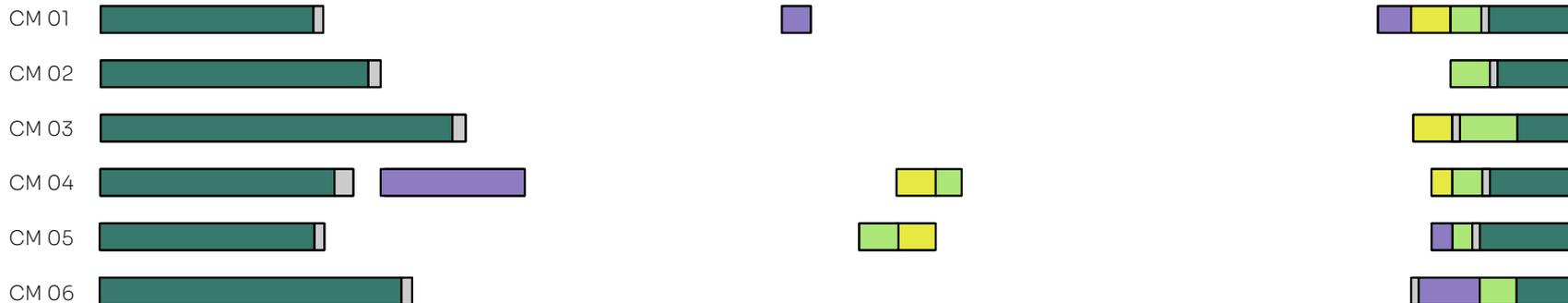
03
Electrical
Engineer/Systems
Technician

04
Atmospheric
Scientist/
Meteorologist

05
Cook/Logistics
Coordinator

06
Communications +
Medical officer

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24



Micro-socializing

Sleeping

Resting

Individual Task

Personal storage

Conceptual idea

Not your workstation

Not your gym

Not your sauna

Not your dinner table

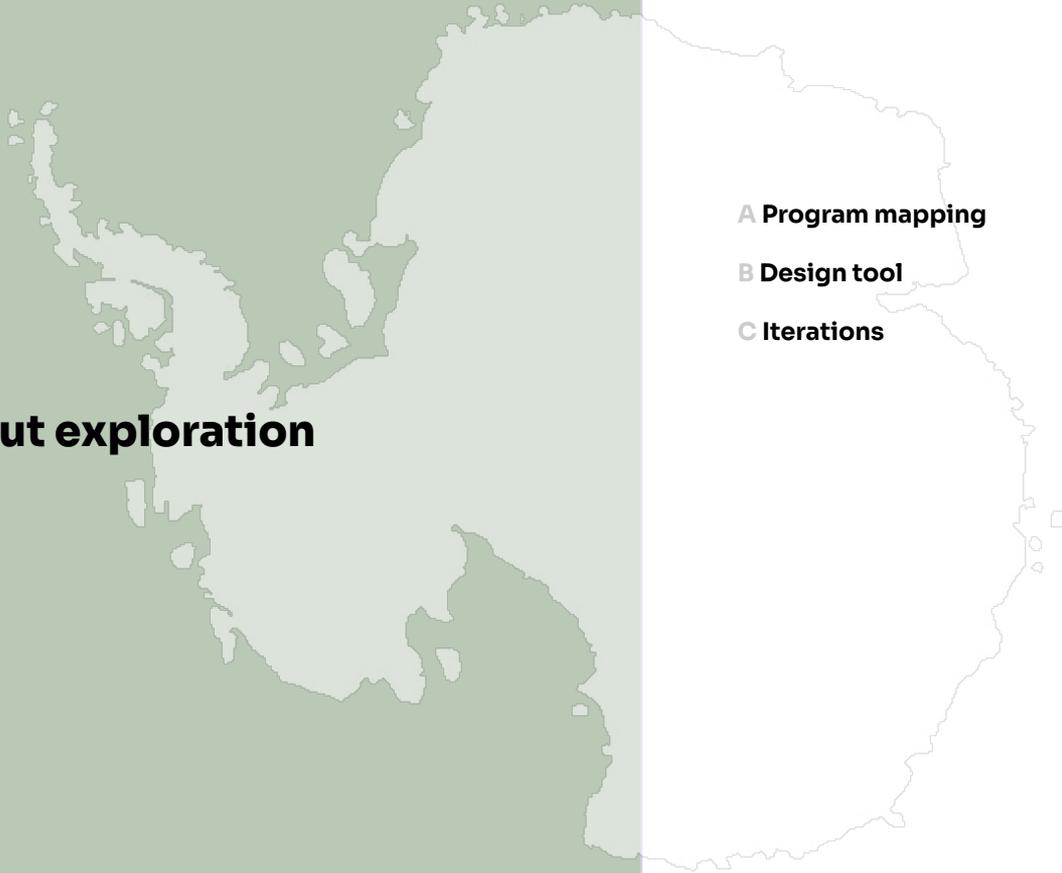
...

It's a place for micro-socialising and retreating,
It boosts you physiological and psychological well-being

In favour of you, your team and the mission.

02

Spatial layout exploration



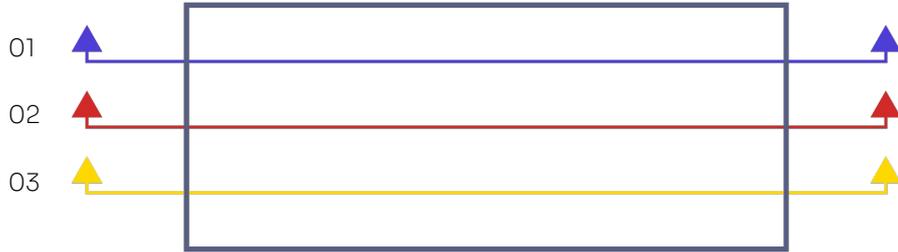
A Program mapping

B Design tool

C Iterations

Shared space
Sleeping
Lounging
Individual Work
Storage

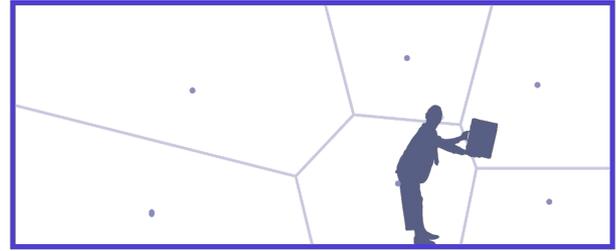
02 Spatial layout exploration **Design tool**



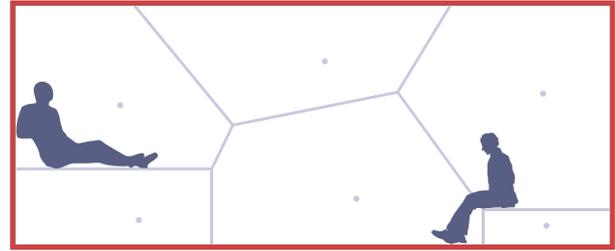
Plan

The plan is divided into a couple of sections through which the 3D voronoi can be manipulated

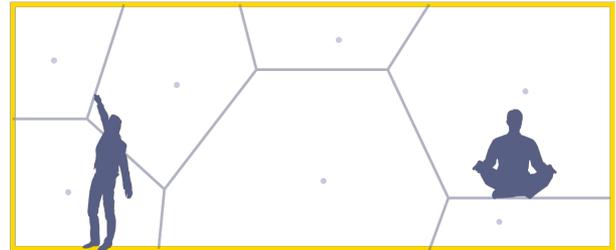
Section 01



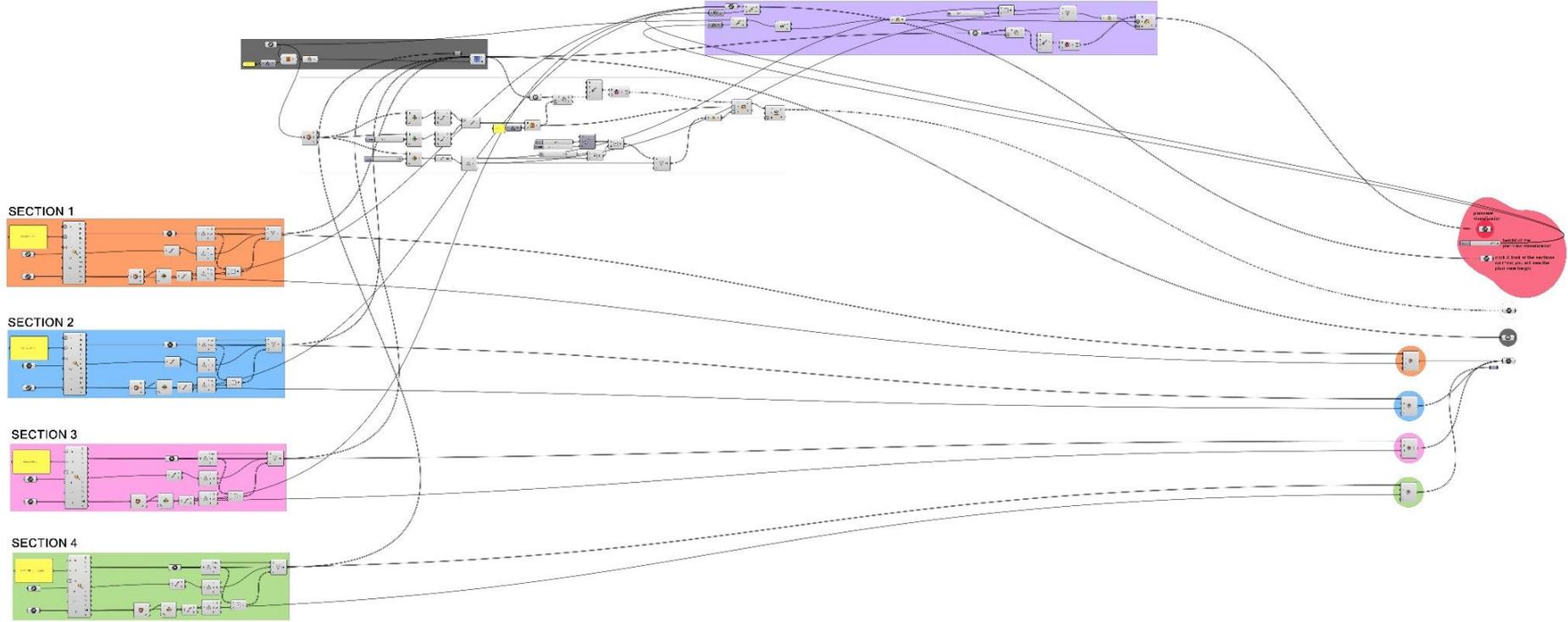
Section 02



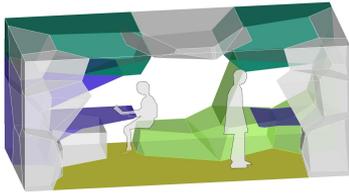
Section 03



O2 Spatial layout exploration **Design tool**



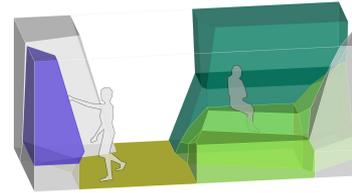
02 Design Process Iterations



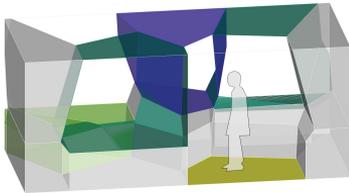
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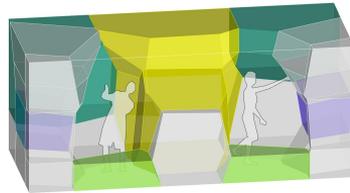
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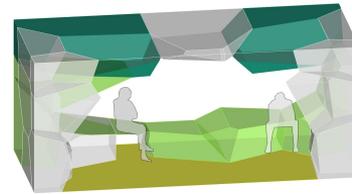
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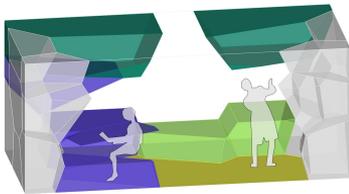
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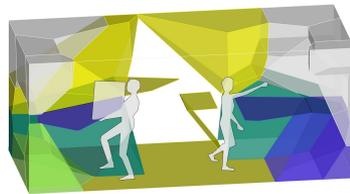
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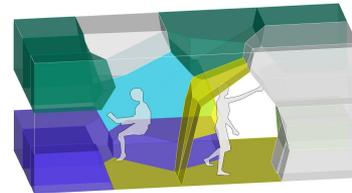
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07



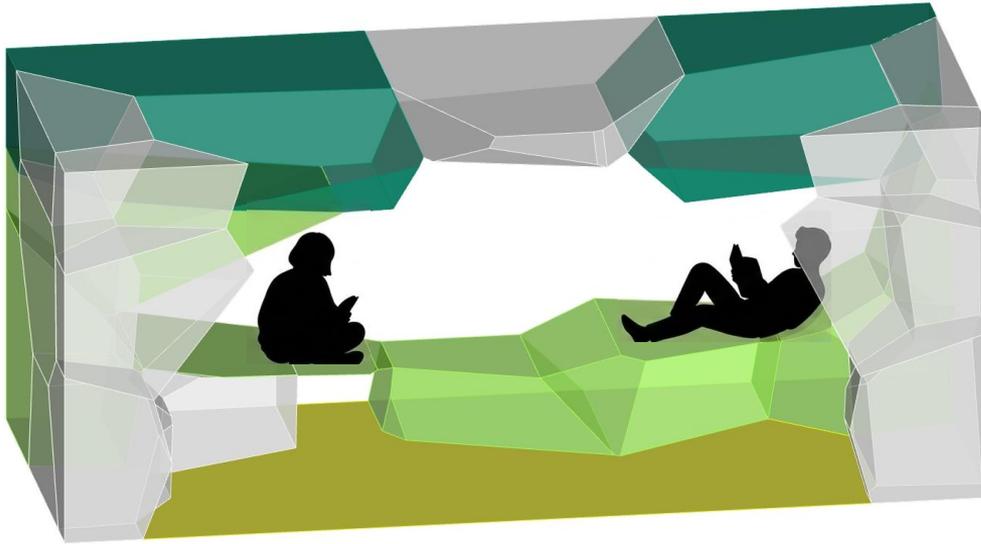
08



09

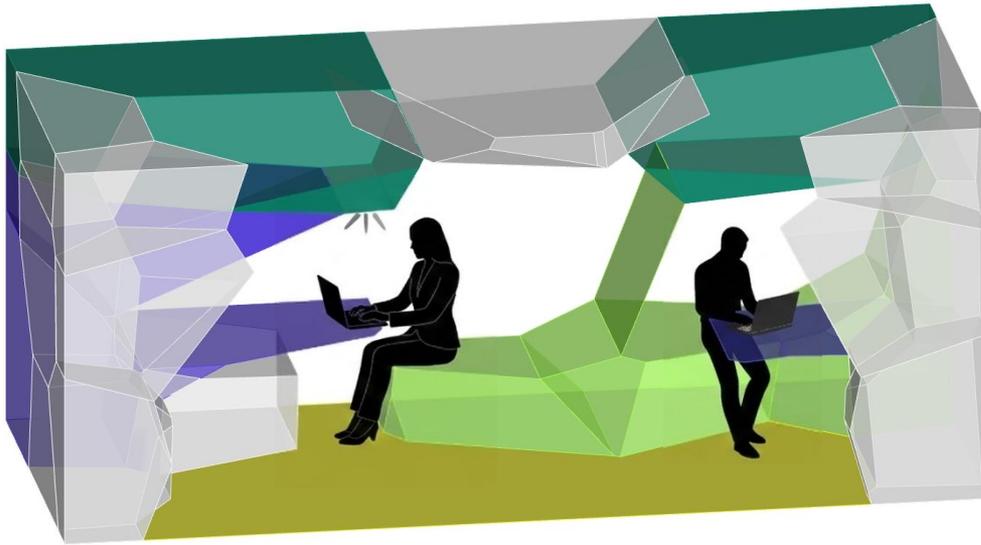
- Shared space
- Sleeping
- Lounging
- Individual work
- Storage

02 Design Process Iterations



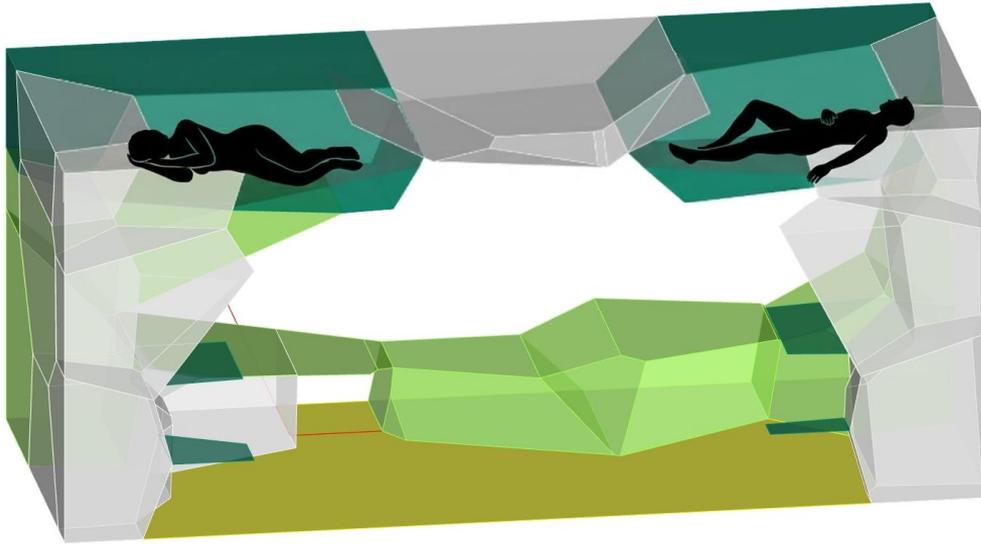
- Shared space
- Sleeping
- Lounging
- Individual work
- Storage

02 Design Process Iterations



- Shared space
- Sleeping
- Lounging
- Individual work
- Storage

02 Design Process Iterations



- Shared space
- Sleeping
- Lounging
- Individual work
- Storage

03 Design

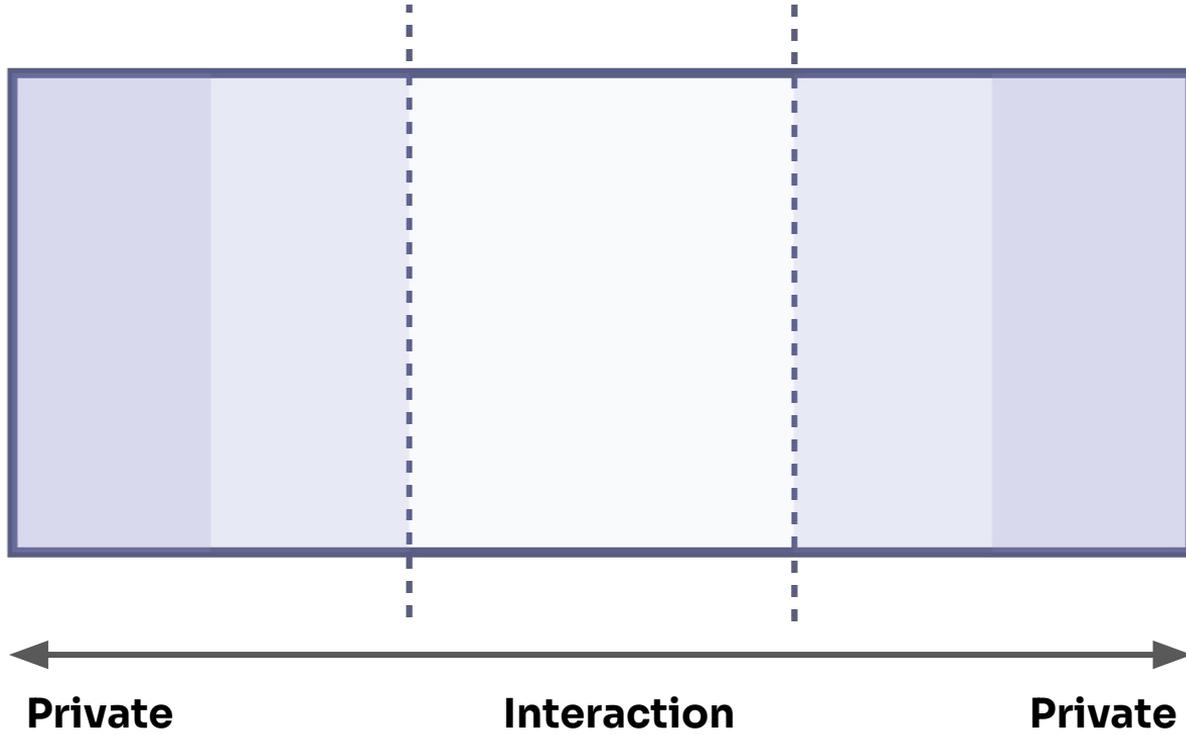


A Spatial modulation & reconfigurability

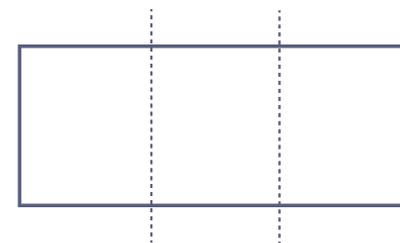
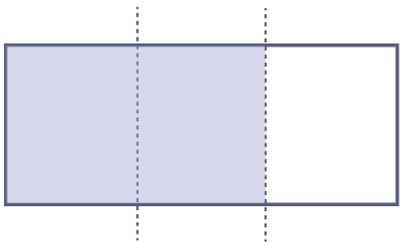
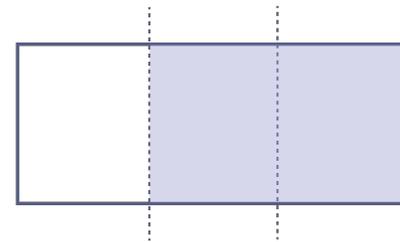
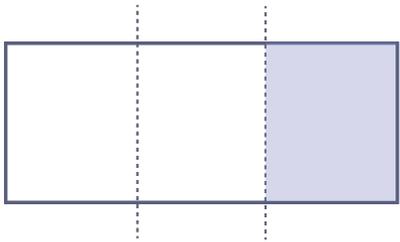
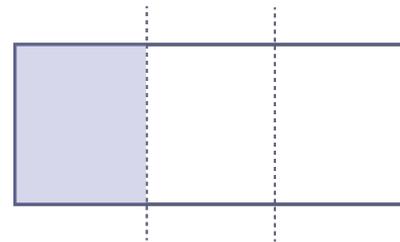
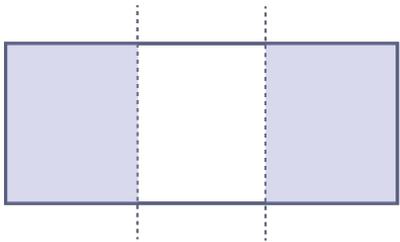
B 3D Voronoi

C Individual reconfiguration

03 Spatial layout exploration **Activities Gradient**

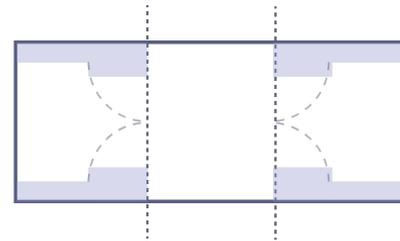
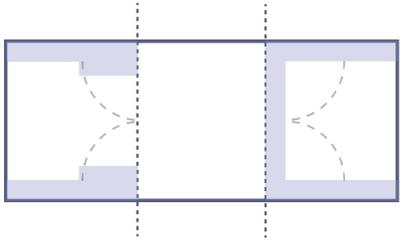
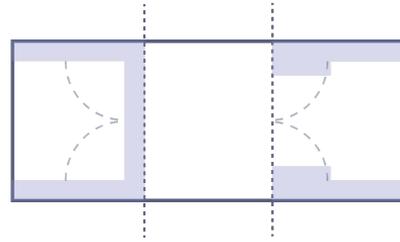
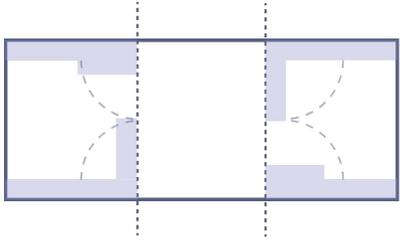
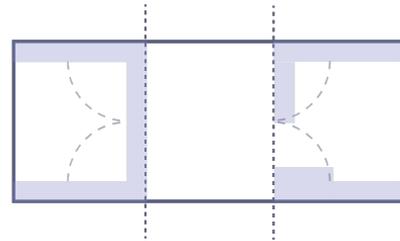
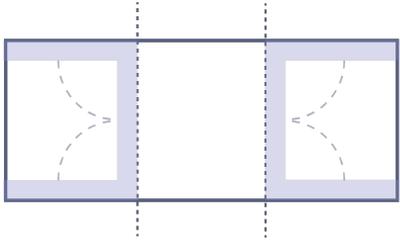


03 Design Scale 01 - Spatial modulation

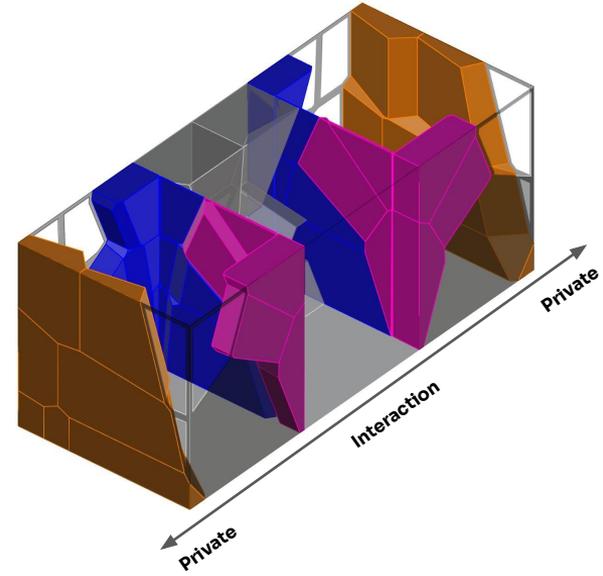
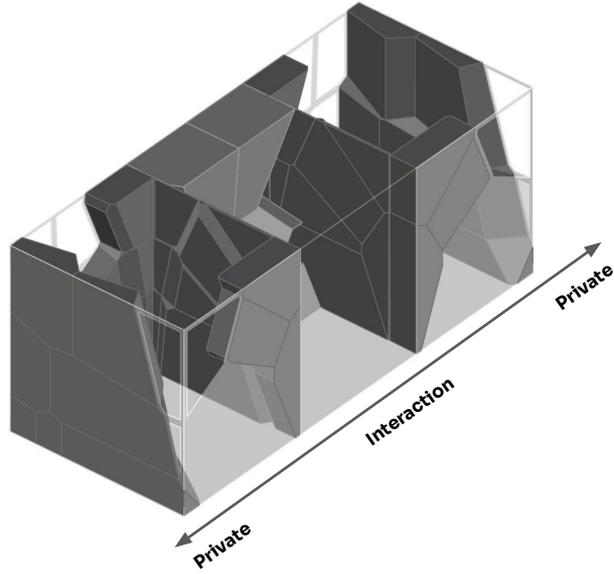
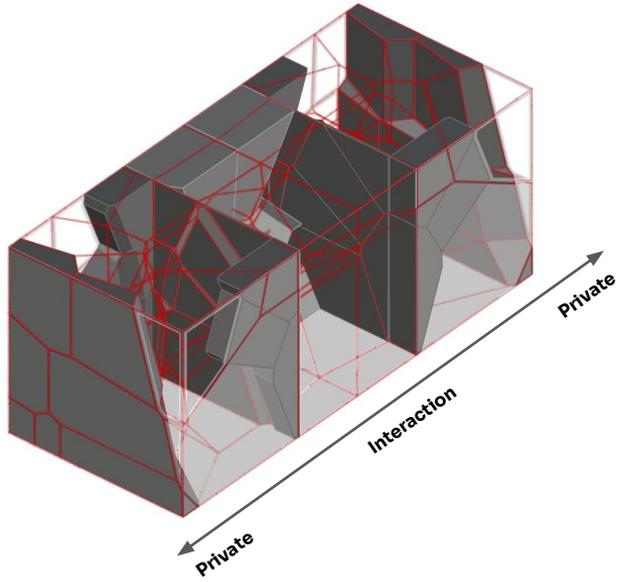


- Interaction
- Private

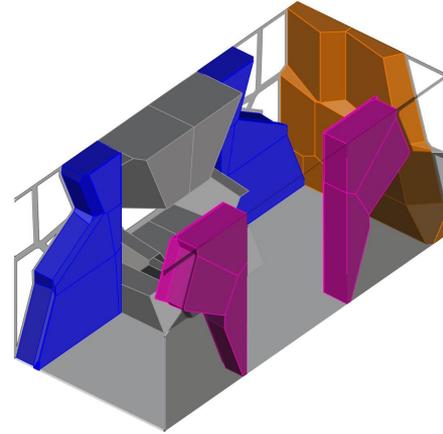
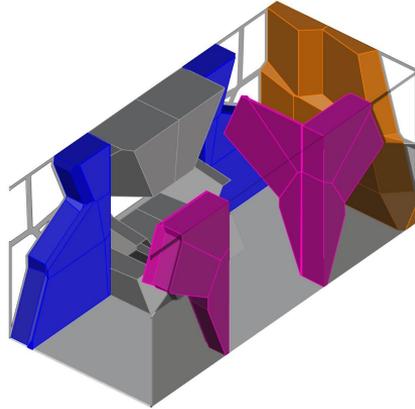
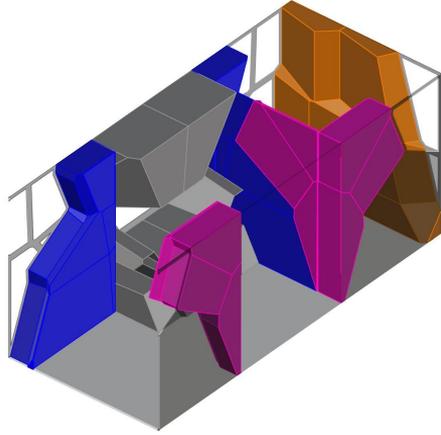
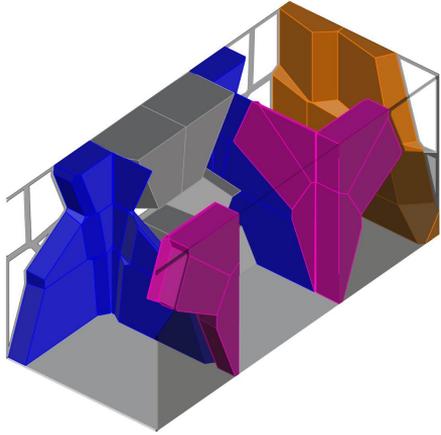
03 Design Scale 02 - Reconfigurability



03 Design Scale 02 - from voronoi to container



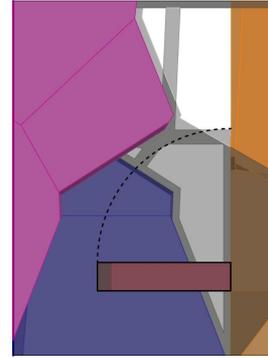
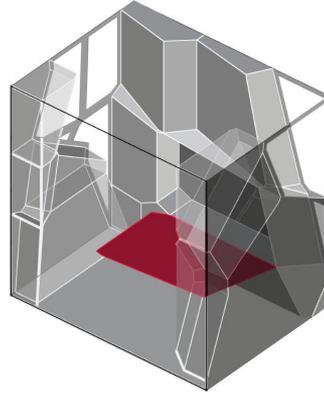
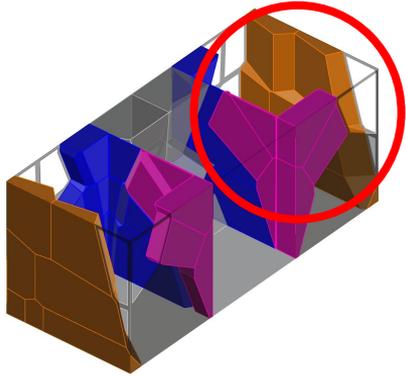
03 Design Scale 02 - Reconfigurability



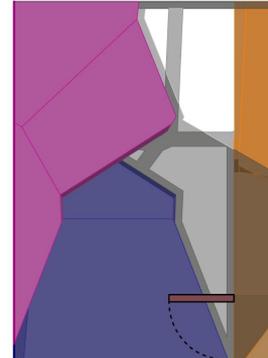
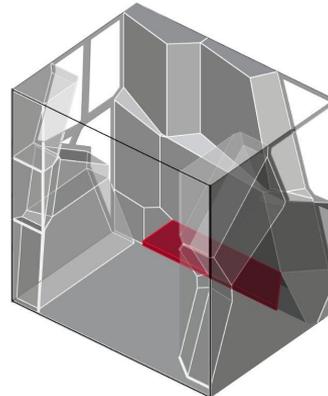
**Close: little
interaction**

**Open:
interaction**

03 Design Scale 02 - Reconfigurability

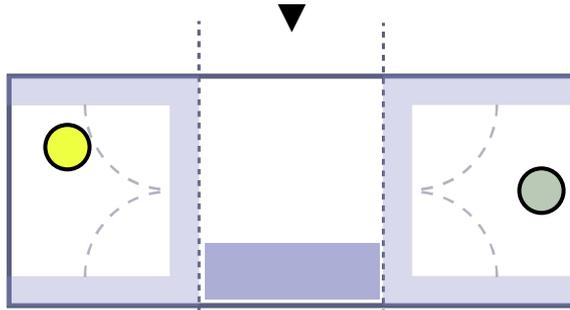


Reconfigurable bed



Reconfigurable lounge

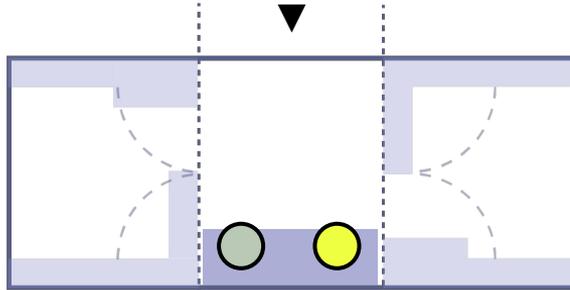
03 Design Scale 02 - Individual reconfiguration



Scenario 01

7:00 AM

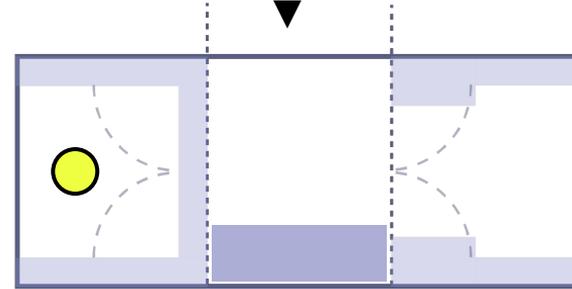
Bob and Sigrid just woke up and are getting out of bed without disturbing each other



Scenario 03

12:30 PM

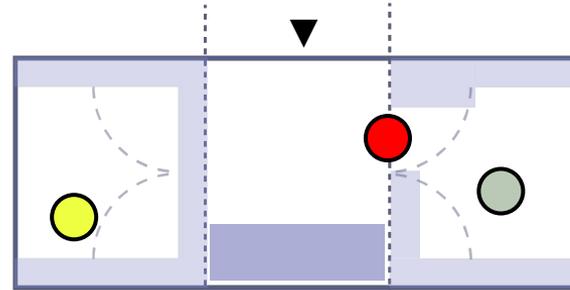
Bob just woke up, Sigrid and Bob have a briefing together in the common space.



Scenario 02

12:00 PM

Bob is taking a nap

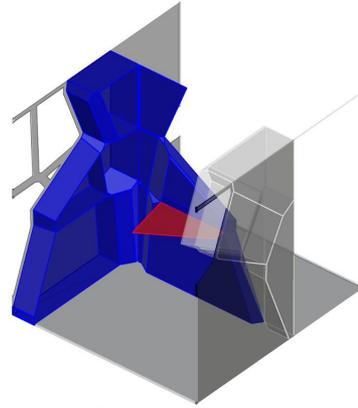
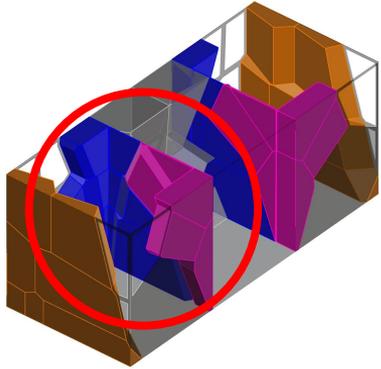


Scenario 04

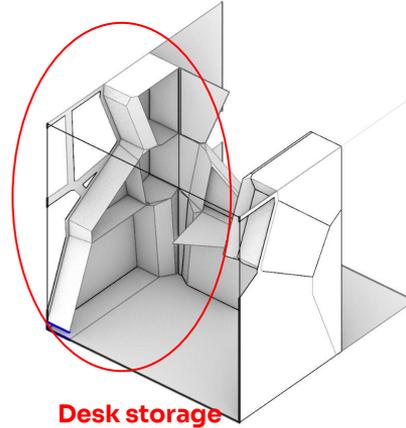
21:30 PM

Bob is calling his partner. Sigrid is having a friend over

03 Design Scale 02 - Reconfigurability - wall

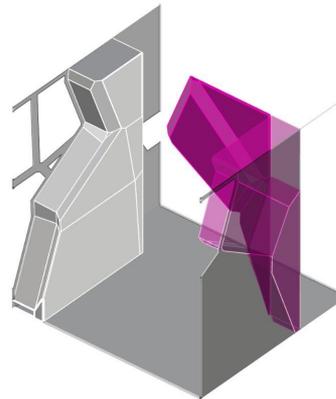


Desk

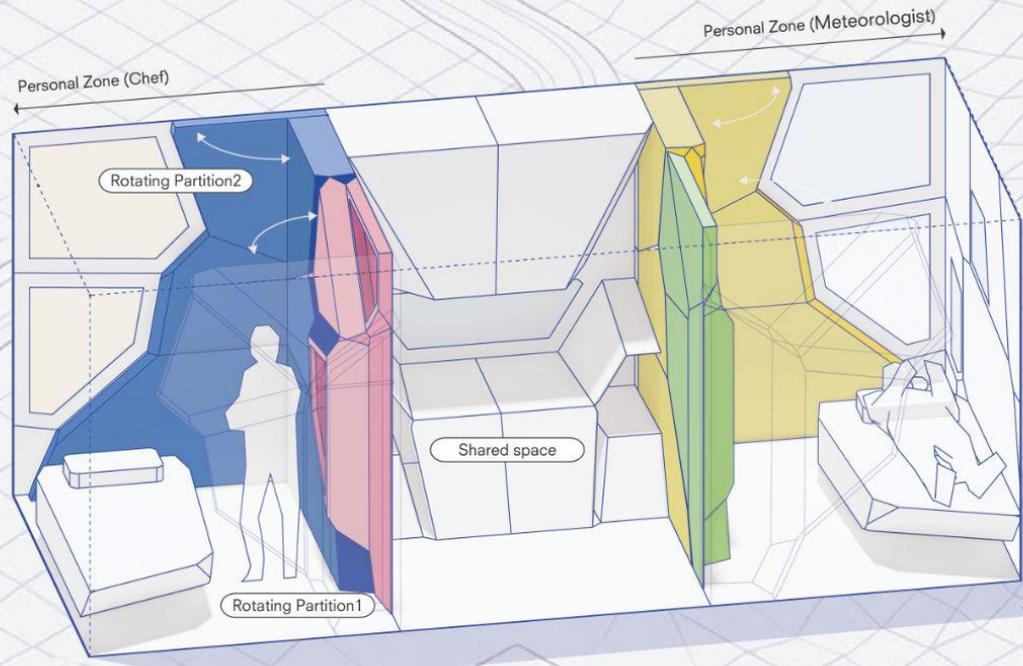


Desk storage

Reconfigurable wall 1:
workstation

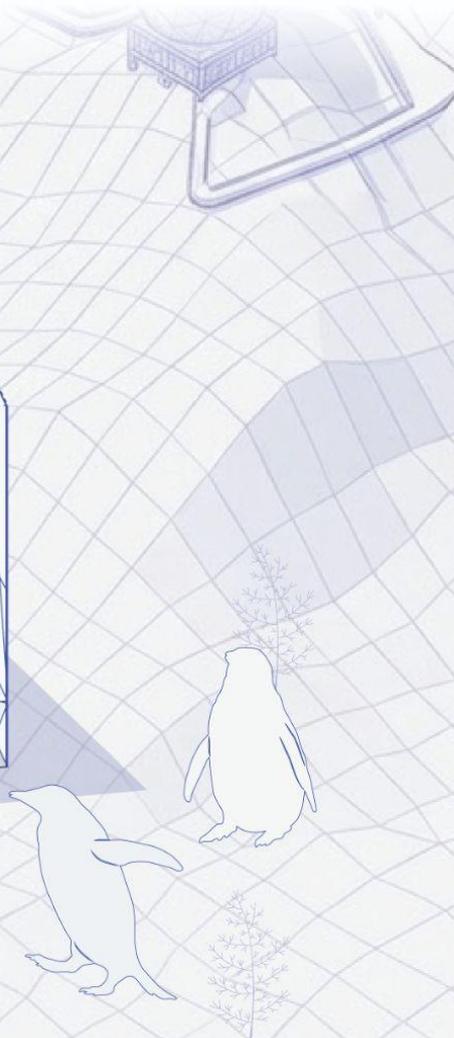


Reconfigurable wall 2:
wardrobe & privacy screen



Daily Scenario 1
Morning 5:00AM

The chef wakes up and gets dressed at the wardrobe. The meteorologist sharing the room is still asleep. All rotating partitions are closed, keeping individual privacy



04

Lighting and AI integration

A Integration of Light in Design

- Skylight (ceiling)
- Light as a Spectacle (windows and walls)
- Individual Light
- Light Therapy

B Goals

C Training the model

- Scatter plots
- Model training
- Evaluation of model
- Visualisation of model

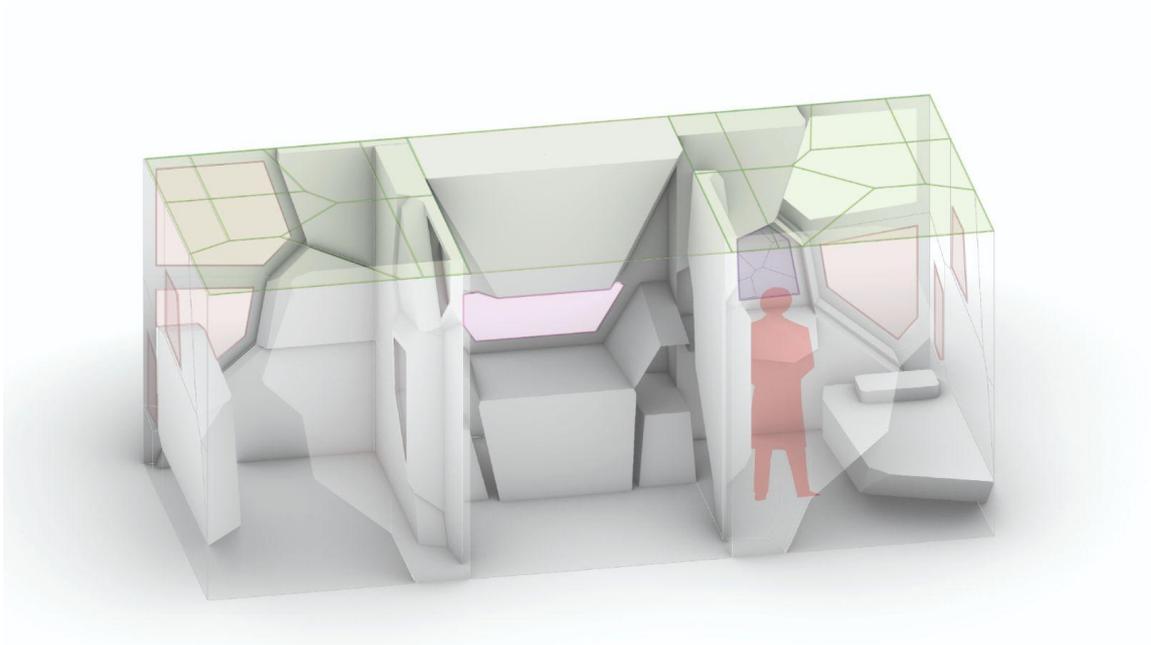
04 Lighting and AI Integration **Lighting types**

(I) Skylight

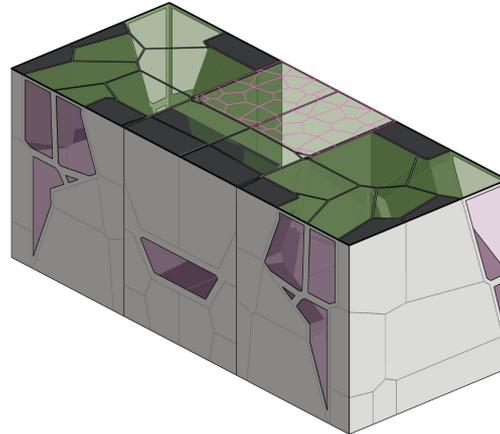
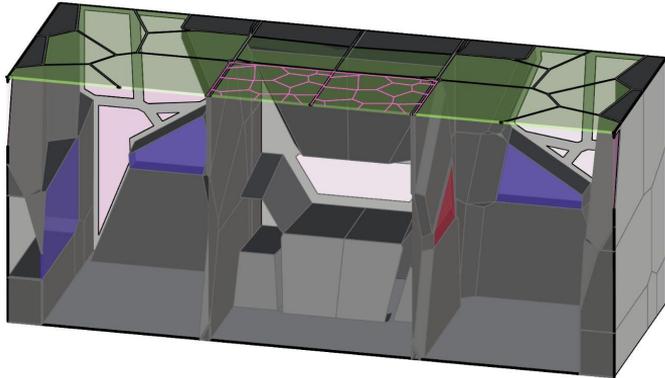
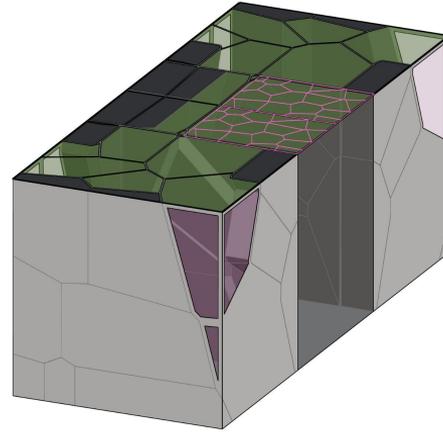
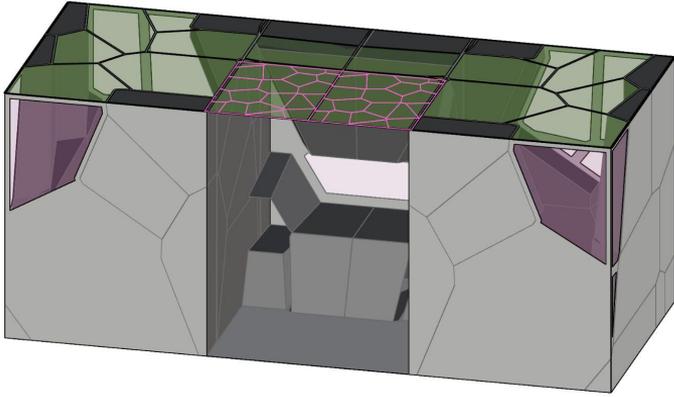
(II) Light as Spectacle

(III) Individual Lighting

(IV) Light Therapy



04 Lighting and AI Integration **Lighting types**



(I) Skylight

(II) Light as Spectacle

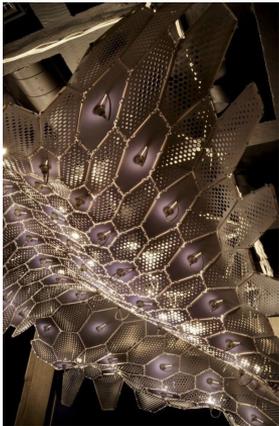
(III) Individual Lighting

(IV) Light Therapy

04 Lighting and AI Integration **Lighting types**

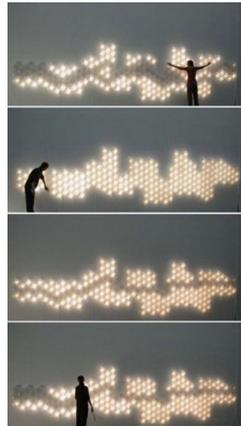
(I) Skylight

- + Human Activity Recognition (HAR)
- + Reacting to a daylight cycle
- + Performative Uses (i.e. Wind blowing through leaves)



(II) Light as Spectacle

- + Computer Vision (CV) translates outdoor environment into spectacle
- + Performative
- + Cognitive Stimulation and Psychological orientation
- + Shows live from outside



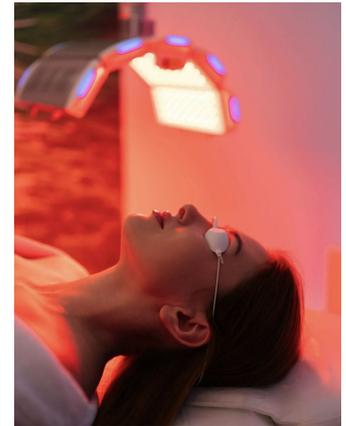
(III) Individual Lighting

- + Autoregressive (AR)
- + Personalized circadian cycle
- + Personalized atmospheric lighting
- + Reaction to physiological factors eg. heart rate



(IV) Light Therapy

- + Red-light (630–850nm) for recovery + mood
- + 10,000 lux daylight therapy for winter activation



O4 Lighting and AI Integration Summary of tutorial

Supervised learning:

- + Input variables / features (weather data and physiological data)
- + Output values / labels (lighting condition generation)

Data Visualization:

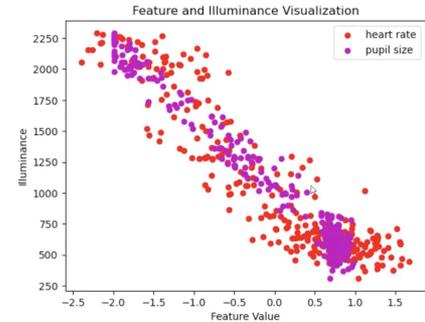
- + Visualizing data sets using scatter plots (show correlations in the data)
- + Understanding the data before training the model for more accuracy

Training the model:

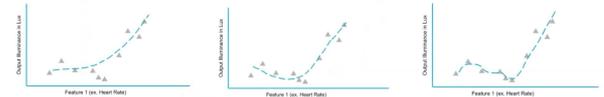
- + Supervised learning regression: learning to predict from data
- + Poor or limited datasets can cause the model to learn incorrect patterns and produce unreliable results

Evaluation of model performance:

- + R square score (MSE, MAE)
- + Evaluation of how well the model is trained to reflect the data accurately



Supervised Learning Regression



04 Lighting and AI Integration **Goals for AI integration**

01: Circadian Rhythm Preservation

- + Simulates a full Delft daylight cycle inside the container
- + Any date selectable — captures seasonal variation across the year
- + Maintains sleep, melatonin and mood cycles during polar night

02: Environmental Energy Optimisation

- + Outdoor conditions drive indoor light levels automatically
- + Bright sun outside —> dims indoor lights
- + Heavy cloud / polar darkness —> boosts indoor light
- + Minimises energy use

03: Personalised Physiological Response

- + Neural network predicts ideal light from body signals
- + High stress detected —> warm dim light to lower heart rate
- + Balanced state —> model prediction applied directly
- + Lighting actively responds to each researcher's biological state

04: Ability to choose own lighting

- + Overrides system lighting for user needs (Have 4 simulation modes for users to choose from - or full RGB range)

(I) Skylight

(II) Light as Spectacle

(I) Skylight

(III) Individual Lighting

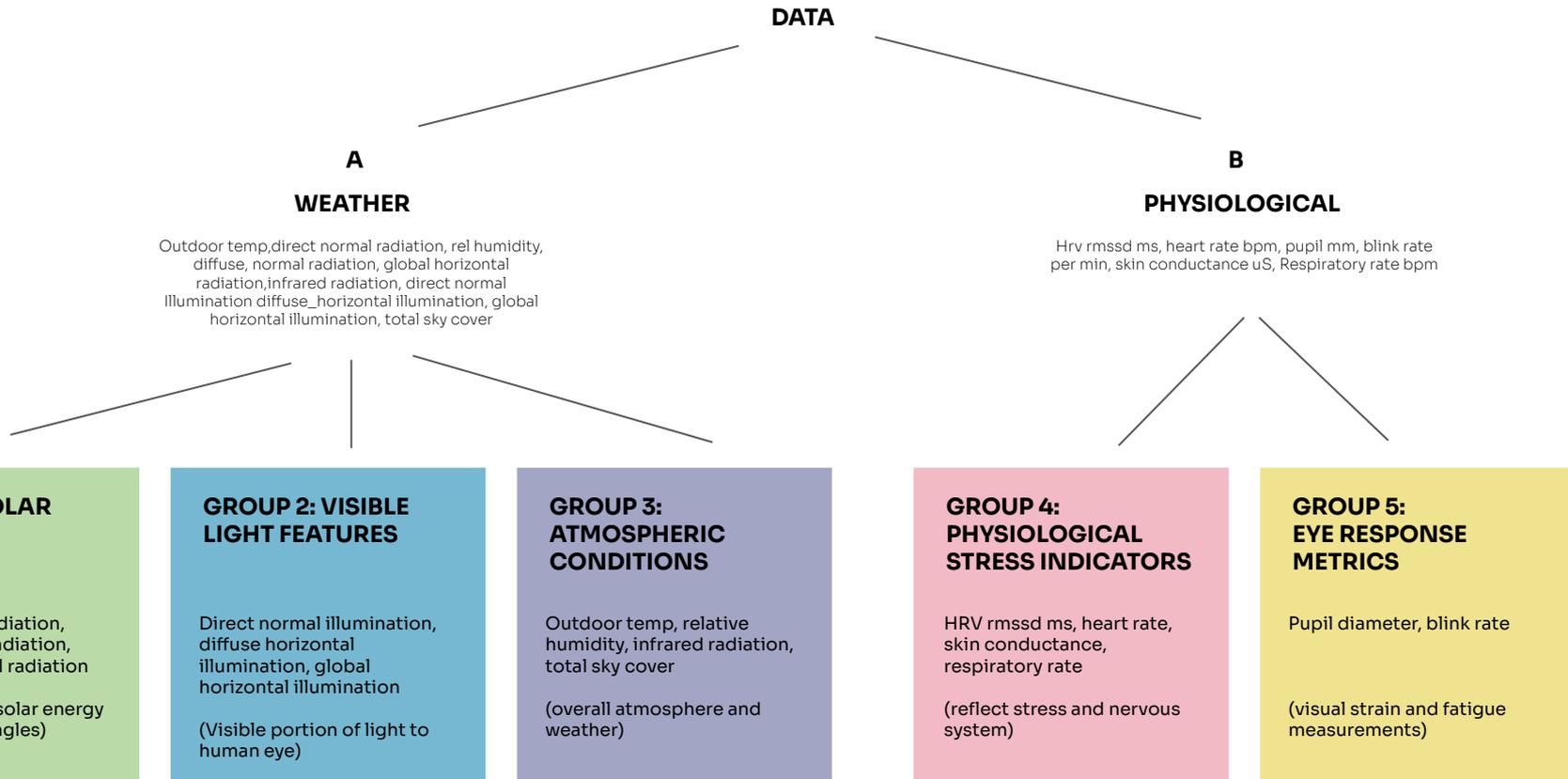
(IV) Light Therapy

(I) Skylight

(III) Individual Lighting



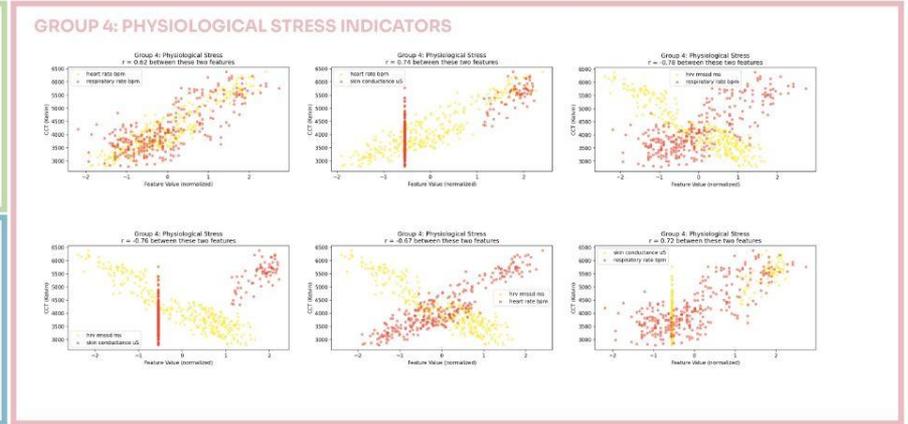
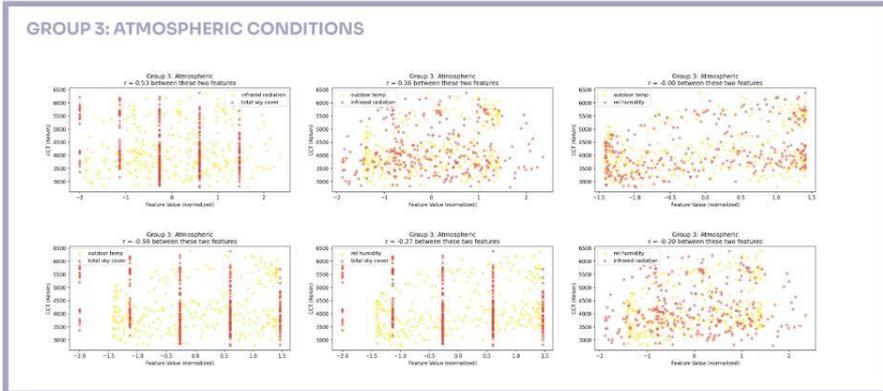
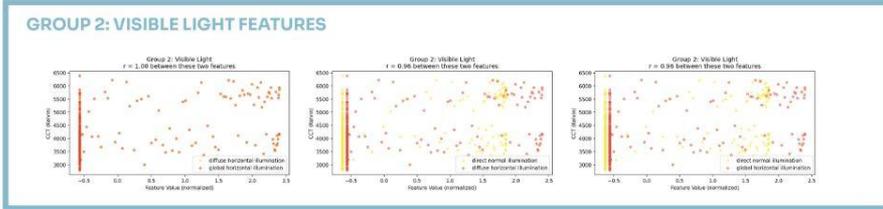
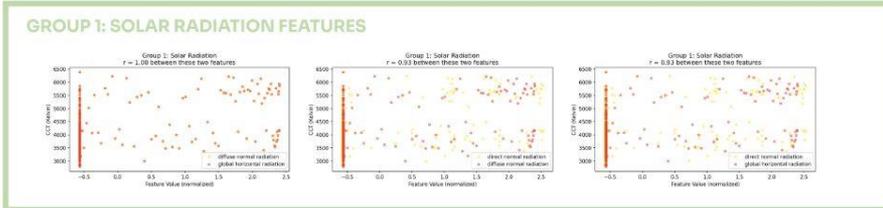
04 Lighting and AI Integration Step 1: Data groupings and scatter maps



O4 Lighting and AI Integration Training the model

Step 1: Data groupings and scatter maps

Between CCT (kelvins) and features (inputs(weather data+physiological data))

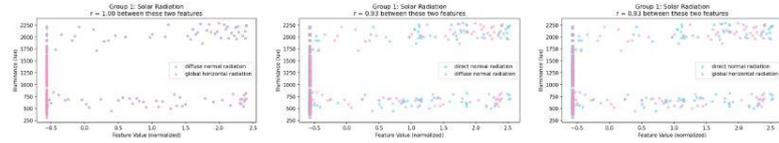


O4 Lighting and AI Integration Training the model

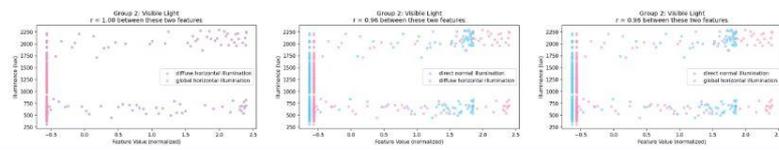
Step 1: Data groupings and scatter maps

Between Illuminance and features (inputs(weather data+physiological data))

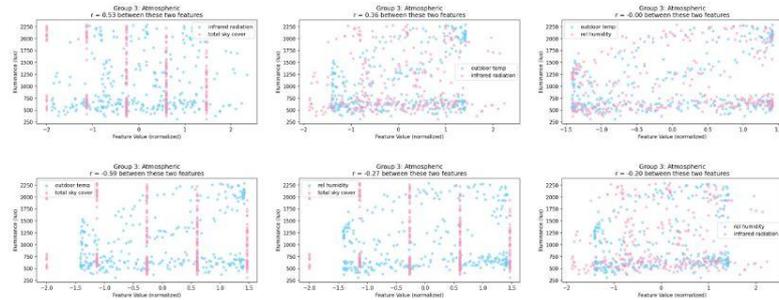
GROUP 1: SOLAR RADIATION FEATURES



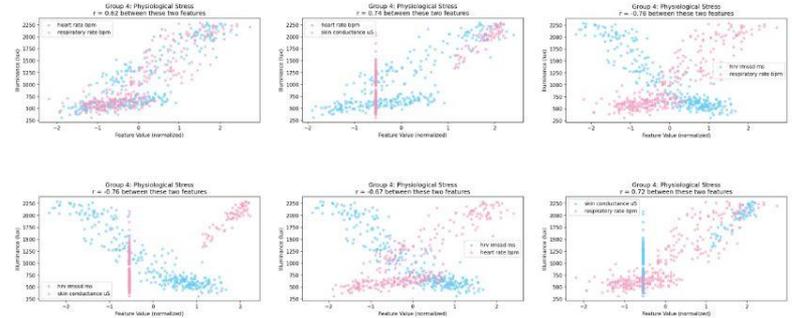
GROUP 2: VISIBLE LIGHT FEATURES



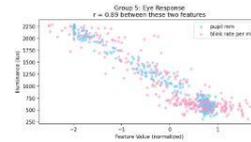
GROUP 3: ATMOSPHERIC CONDITIONS



GROUP 4: PHYSIOLOGICAL STRESS INDICATORS



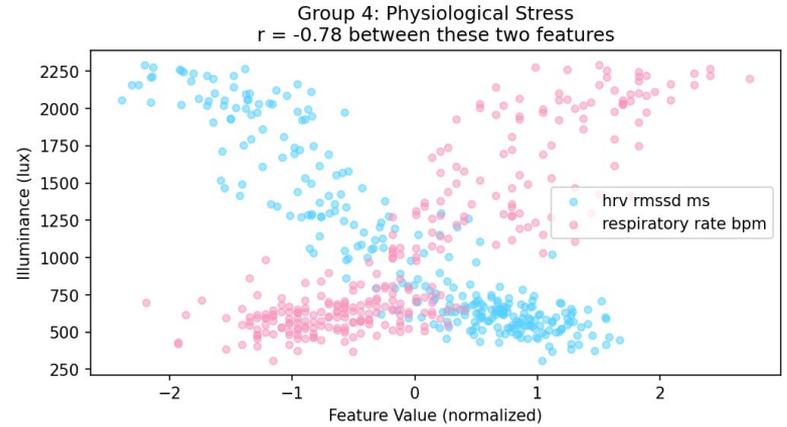
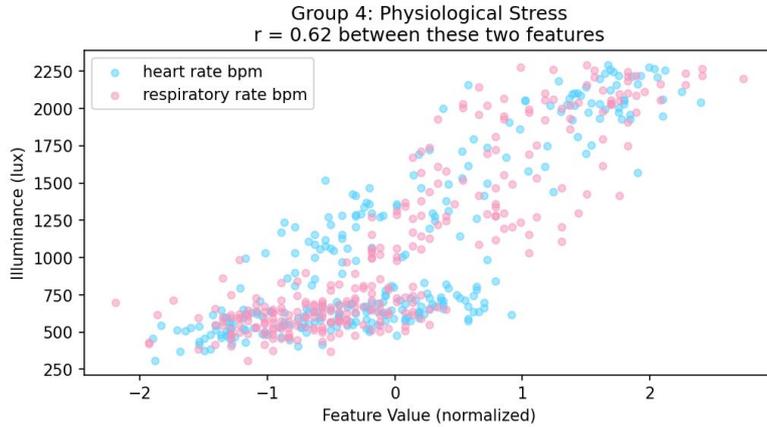
GROUP 5: EYE RESPONSE METRICS



O4 Lighting and AI Integration Training the model

Step 1: Data groupings and scatter maps

Between Illuminance and features (inputs(weather data+physiological data))



O4 Lighting and AI Integration Training the model

Step 1: Data groupings and scatter maps

Summary of findings

Group 01: Solar Radiation features

- + All features show similar trends
- + Keep **Direct normal radiation** (Most direct measurement of incoming solar energy)

Group 02: Visible light features

- + All features show similar trends
- + Keep **Direct normal illumination** (Visible spectrum)

Group 03: Atmospheric conditions

- + Weak to moderate correlations
- + Keep **Outdoor temp and Total sky cover** (Most important for energy savings mode)

Group 04: Physiological stress indicators

- + Weak to moderate correlations - keep more features
- + Keep **hrv rmssd ms, heart rate bpm, skin conductance** (most relevant features and capture opposite ends of spectrum)

Group 05:

- + Similar trends
- + Keep **pupil size** (most able to reflect lighting)

Final features model was trained on:

- + **Direct Normal Radiation**
- + **Direct Normal Illumination**
- + **Outdoor Temp**
- + **Total Sky Cover**
- + **HRV RMSSD MS**
- + **Heart Rate BPM**
- + **Skin Conductance**
- + **Pupil size**

04 Lighting and AI Integration Training the model

Step 2: Training the model

[25]: *#Remove or add features to the weather and physiological features list here usein the All Feature and Label Options list above as reference,*

```
#Weather Features
weather_data_all = ['outdoor_temp', 'direct_normal_radiation', 'direct_normal_illumination', 'total_sky_cover']

#Physiological featrues
physiological_data_all = ['hrv_rmssd_ms', 'heart_rate_bpm', 'pupil_mm', 'skin_conductance_uS']
#Label Options
illuminance = 'illuminance_lux'
cct = 'cct_kelvin'
```

```
# Import train_test_split function
from sklearn.model_selection import train_test_split

# Split dataset into training set and test set
X_2_train, X_2_test, y_2_train, y_2_test = train_test_split(X_2_norm, y_2, test_size=0.3, random_state=42) # 70% training and 30% test

#Train a regression model using the MLPRegressor function
#https://scikit-learn.org/stable/modules/generated/sklearn.neural_network.MLPRegressor.html#sklearn.neural_network.MLPRegressor

from sklearn.neural_network import MLPRegressor

mlp_2 = MLPRegressor(hidden_layer_sizes=(50, 50, 50, 50), activation='relu', solver='adam', max_iter=1000)
mlp_2.fit(X_2_train, y_2_train)

predict_train_2 = mlp_2.predict(X_2_train)
y_pred_2 = mlp_2.predict(X_2_test)

print('training complete')

training complete
```

O4 Lighting and AI Integration **Training the model**

Step 3: Evaluation of model

Evaluation tools:

- + **R-squared:** Accuracy of model in %
- + **Root mean squared error:** Average size of prediction errors in %
- + **Mean absolute error:** typical prediction error in units

Illuminance:

- + r-squared is 0.9635652190910206
- + root mean squared error is 112.47336167325606
- + mean absolute error is 86.35875507688202

96% accurate: Strong predictive performance

CCT:

- + r-squared is 0.8595488325766288
- + root mean squared error is 335.2328948281677
- + mean absolute error is 242.07912366948045

85% accurate: Good predictive performance

O4 Lighting and AI Integration Training the model

Step 4: Adding complexity to model

Daylight Simulation model

+ Training model on Netherlands Bilt Data (For seasonal variation)

```
##DAYLIGHT ILLUMINANCE/CCT PER MONTH AND HOUR##

[55]: import warnings
import numpy as np
warnings.filterwarnings('ignore')

month = 12
hour = 12

sunrise = {1:8, 2:8, 3:7, 4:6, 5:5, 6:5, 7:5, 8:6, 9:7, 10:7, 11:7, 12:8}
sunset = {1:17, 2:18, 3:19, 4:20, 5:21, 6:22, 7:21, 8:20, 9:19, 10:18, 11:17, 12:16}

if hour < sunrise[month] or hour >= sunset[month]:
    print(f'Predicted illumination: 0 lux (night)')
else:
    solar_noon = (sunrise[month] + sunset[month]) / 2
    day_length = sunset[month] - sunrise[month]
    # simpler linear falloff from noon
    sun_angle = 1 - abs(hour - solar_noon) / (day_length / 2)
    sun_angle = max(0, sun_angle)

    defaults = monthly_defaults[month]
    prediction = mlp_daylight.predict(scaler_daylight.transform([[
        month, hour,
        defaults['outdoor_temp'],
        defaults['total_sky_cover'],
        defaults['global_horizontal_radiation'] * sun_angle
    ]]))

    final_lux = max(0, prediction[0] * sun_angle)
    print(f'Predicted illumination: {final_lux:.0f} lux')

Predicted illumination: 2221 lux
```

```
[56]: # Direct CCT calculation from lux - no model needed
# Low lux = warm (2700K), high lux = cool (6500K)
max_outdoor_lux = 20000 # June noon max
final_cct = int(2700 + (final_lux / max_outdoor_lux) * (6500 - 2700))
final_cct = max(2700, min(6500, final_cct))

print(f'Predicted illumination: {final_lux:.0f} lux')
print(f'Predicted CCT: {final_cct}K')

Predicted illumination: 2221 lux
Predicted CCT: 3121K
```

+ The model predicts both illuminance and colour temperature, replicating how light changes across seasons and times of day. **Can modify hour/month**

04 Lighting and AI Integration Training the model

Step 5: Visualization of model

01 — DAYLIGHT SIMULATION 02 — ENERGY SAVING 03 — PHYSIOLOGICAL CONTROL

Simulate any Delft day inside the Antarctic container

Pick a date and hour — the system calculates the exact lux and colour temperature that would occur naturally in Delft at that moment, and replicates it indoors.

Select Delft Date

2025/06/04

Delft Daylight — June 04

Current Hour

7:00

SUNRISE → SUNSET

3:9:00 → 20:1:00

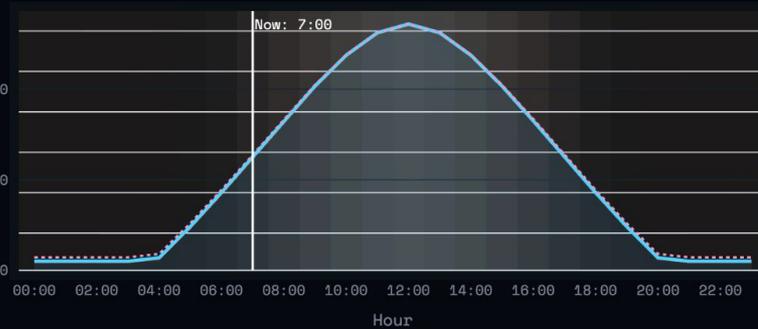
DAYLIGHT HOURS

16.2 hrs

3471K · 626 lux

🔦 RELAXED FOCUS

Illuminance (lux)



Seasonal Comparison

All Four Seasons — Indoor Lux Target

04 Lighting and AI Integration Training the model

Step 5: Visualization of model

01 — DAYLIGHT SIMULATION **02 — ENERGY SAVING** 03 — PHYSIOLOGICAL CONTROL

Outdoor conditions → Indoor light adjustment

When it's bright outside, the system dims indoor lights to save energy. High cloud cover or polar darkness triggers more indoor light.

Outdoor Conditions

Direct Solar Radiation (W/m²)



Cloud Cover (0–10)



Outdoor Temperature (°C)



Relative Humidity (%)



Adjusted Indoor Lighting

Indoor Lux

763

Energy Saved

67%

Solar Offset

-407 lux



How outdoor conditions adjust indoor lux

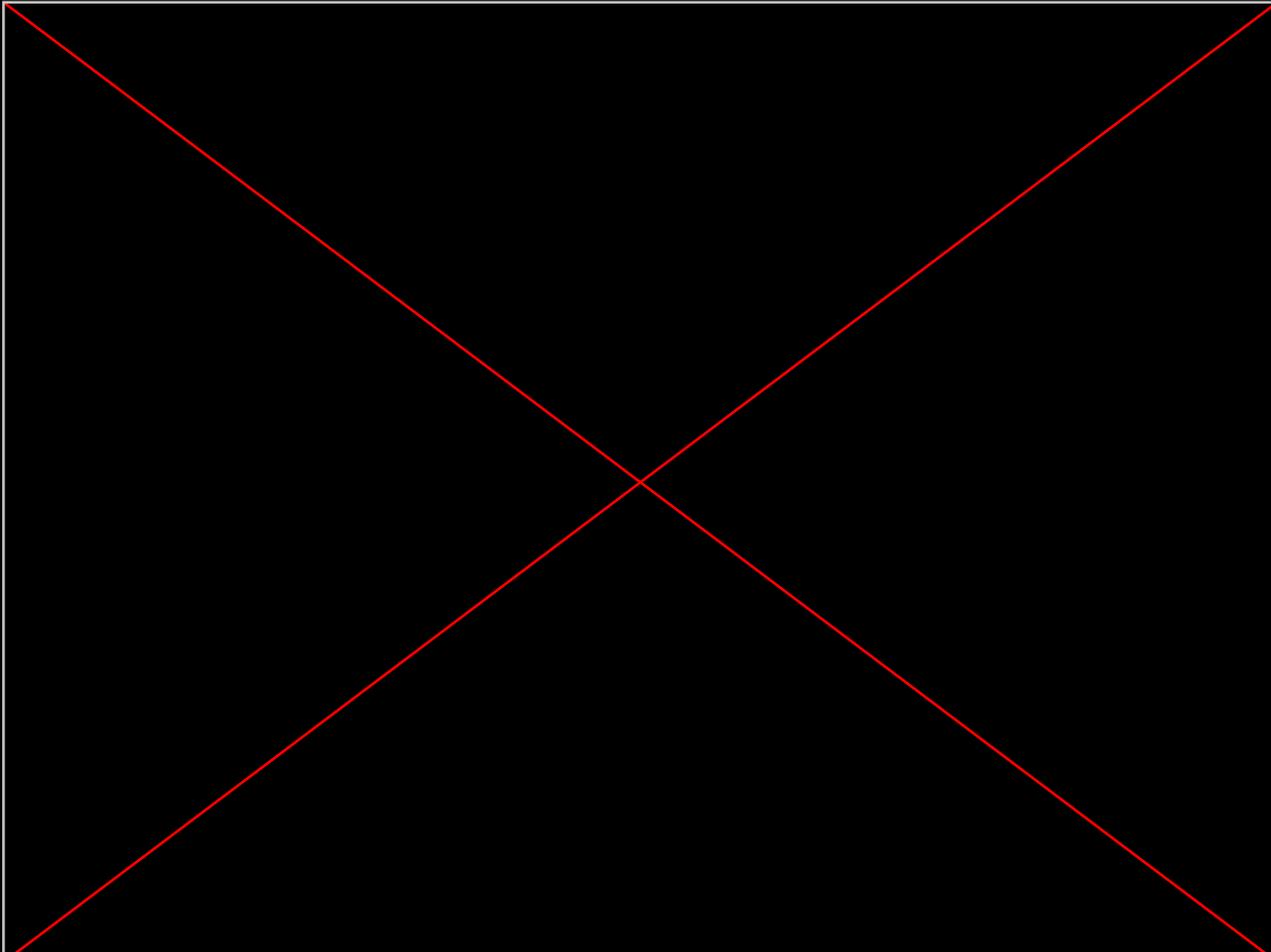
04 Lighting and AI Integration Training the model

Step 5: Visualization of model



04 Lighting and AI Integration Training the model

Step 5: Visualization of model



Thank you

:>]